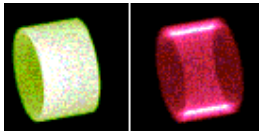
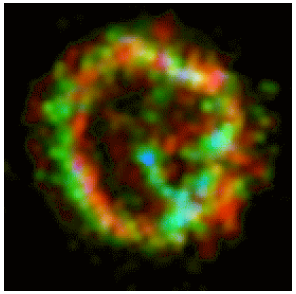
SNR E0102: Measured Velocities and Geometric Musings

by Dan Dewey, MIT

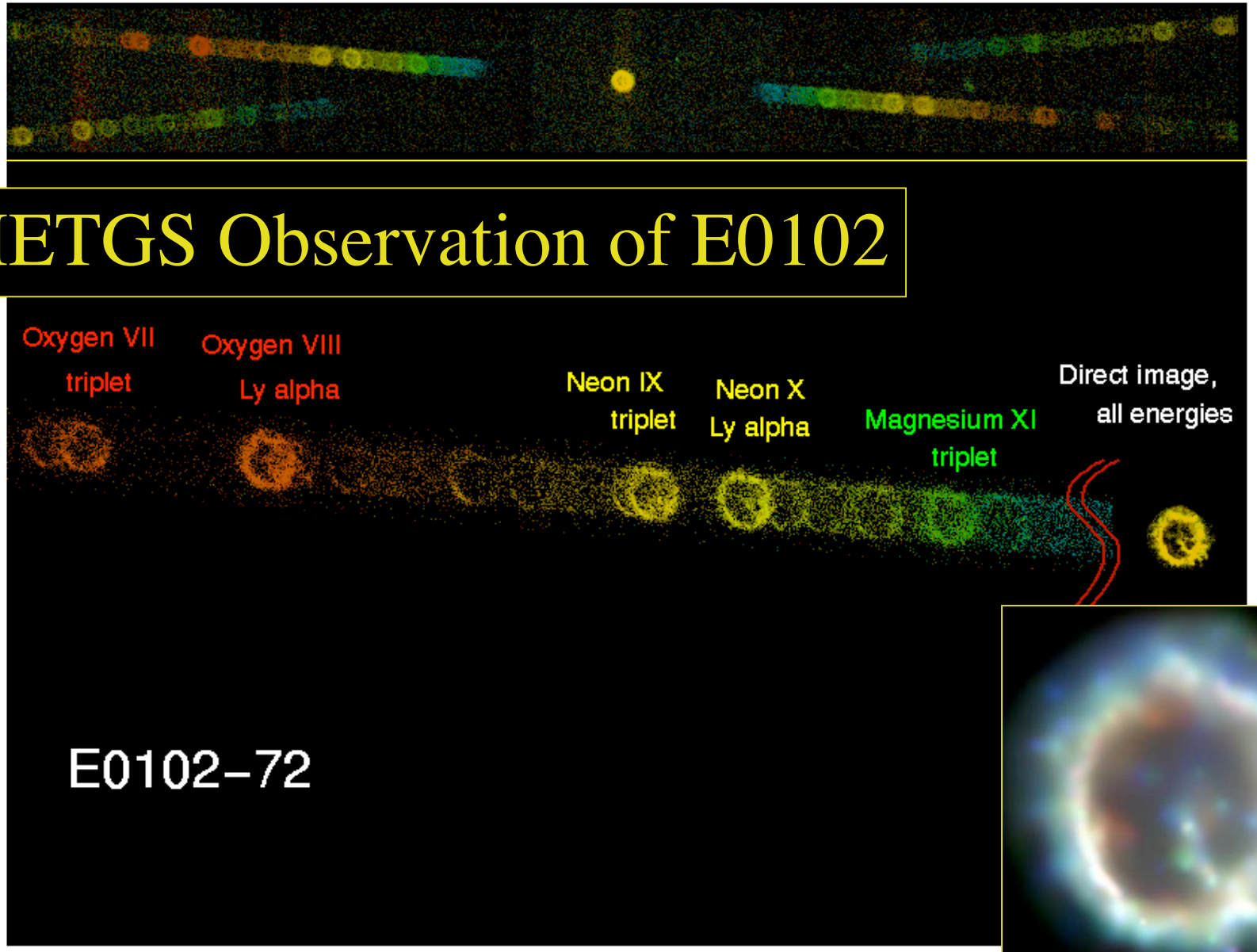
- Extraction of spatial-velocity information from HETGS observation



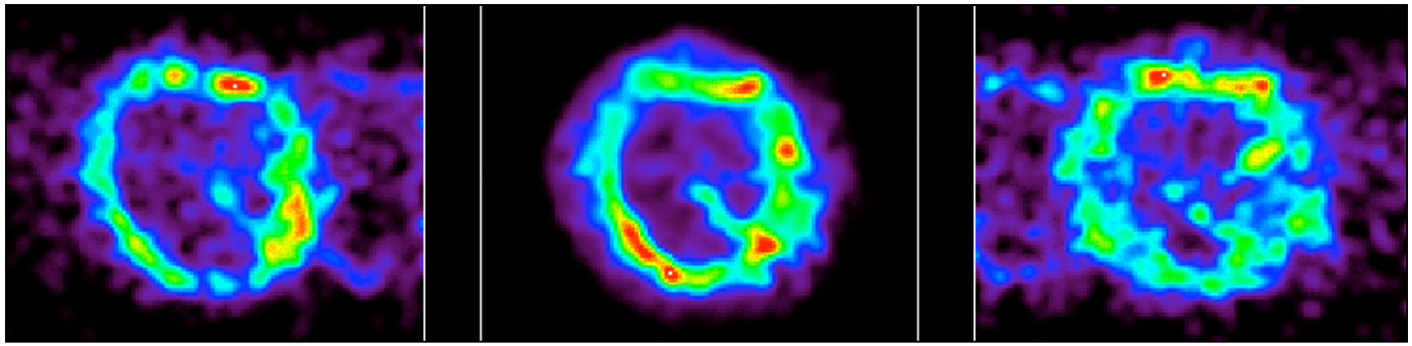


- 3-D modeling of E0102 Ne X emission
- Are SNRs Optically thin? Everywhere?

HETGS Observation of E0102

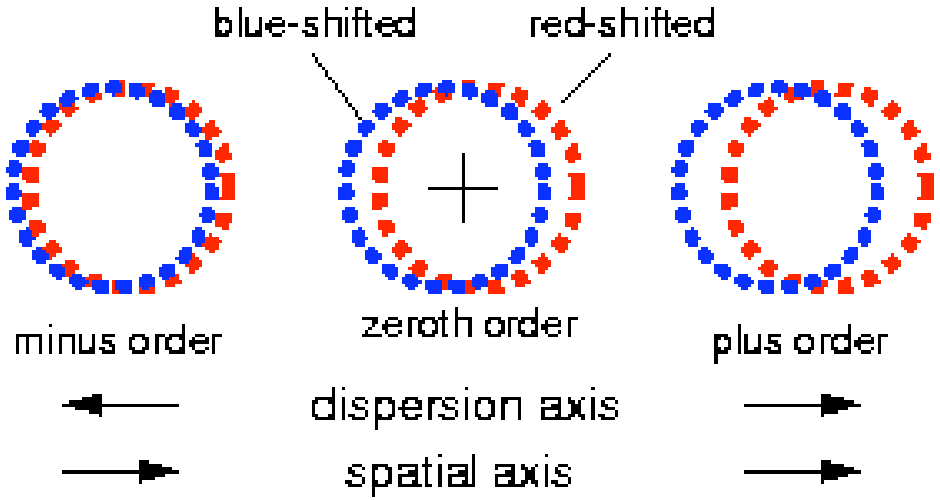


Ne X line images

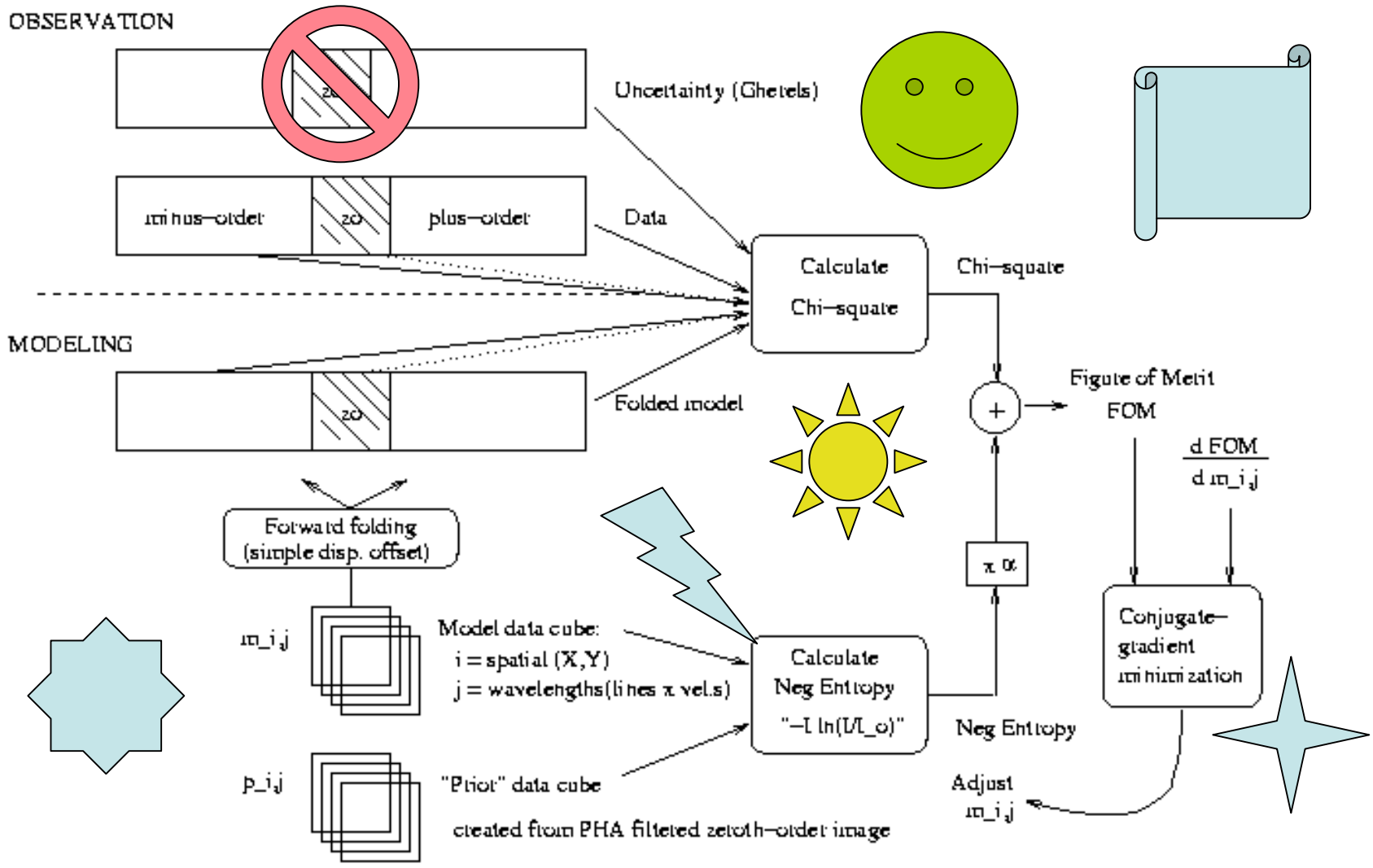


Minus order Zeroth-order Plus order

- Usefulness of plus, minus, and zeroth order data
- Asymmetry in Ne X image: simple explanation:



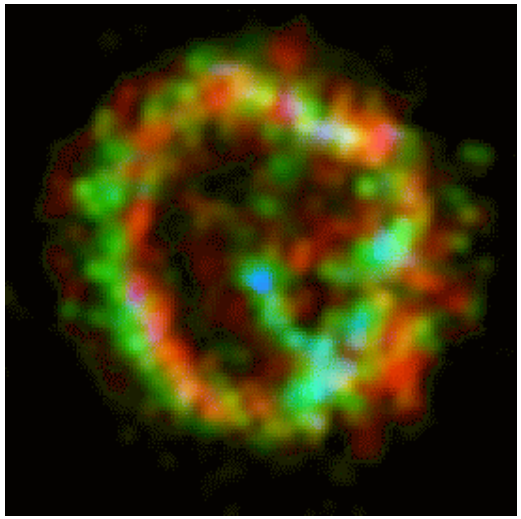
Something too complex to explain happens



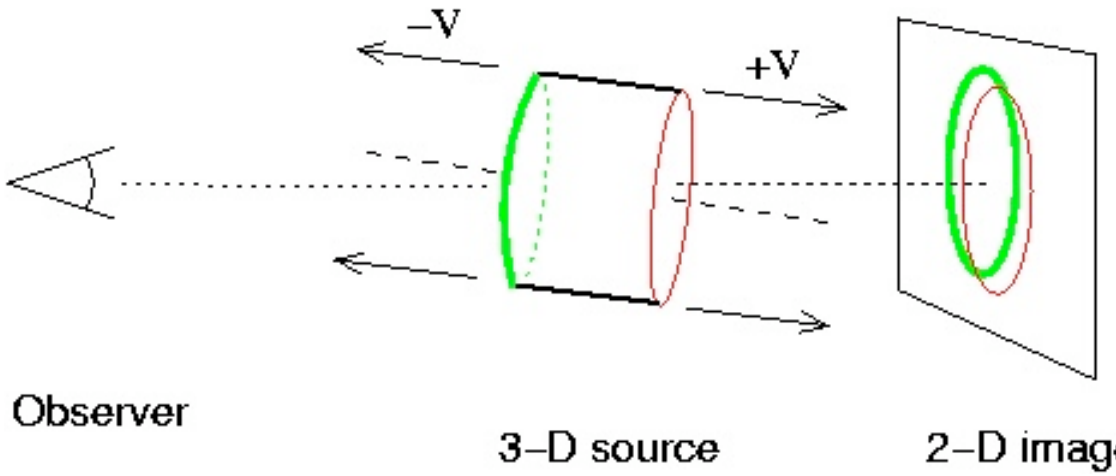
Color-velocity image results

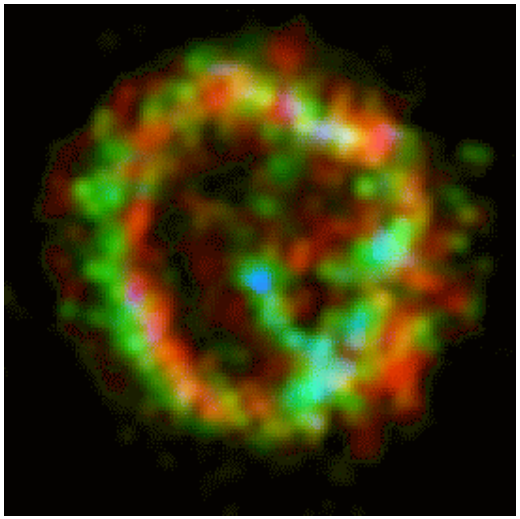
Regions of red and blue shift appear as displaced rings.

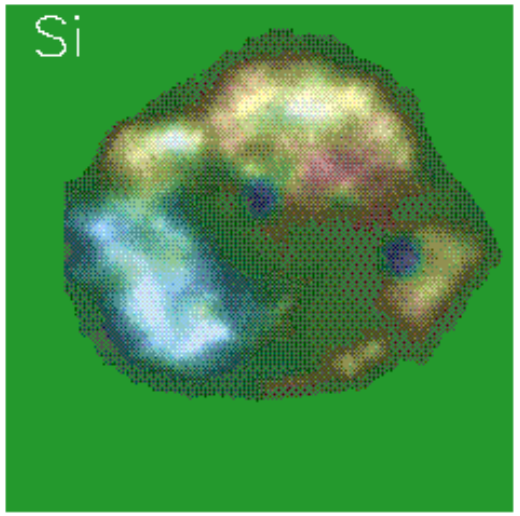
- Red: 900 and 1800 km/s
- Green: -900 km/s
- Blue: -1800 km/s



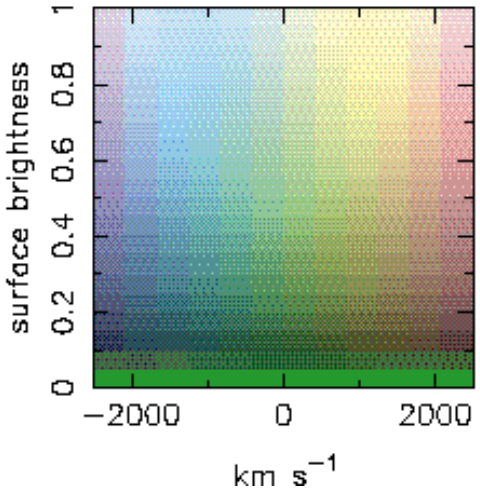
- Interpretation as cylinder viewed almost end-on





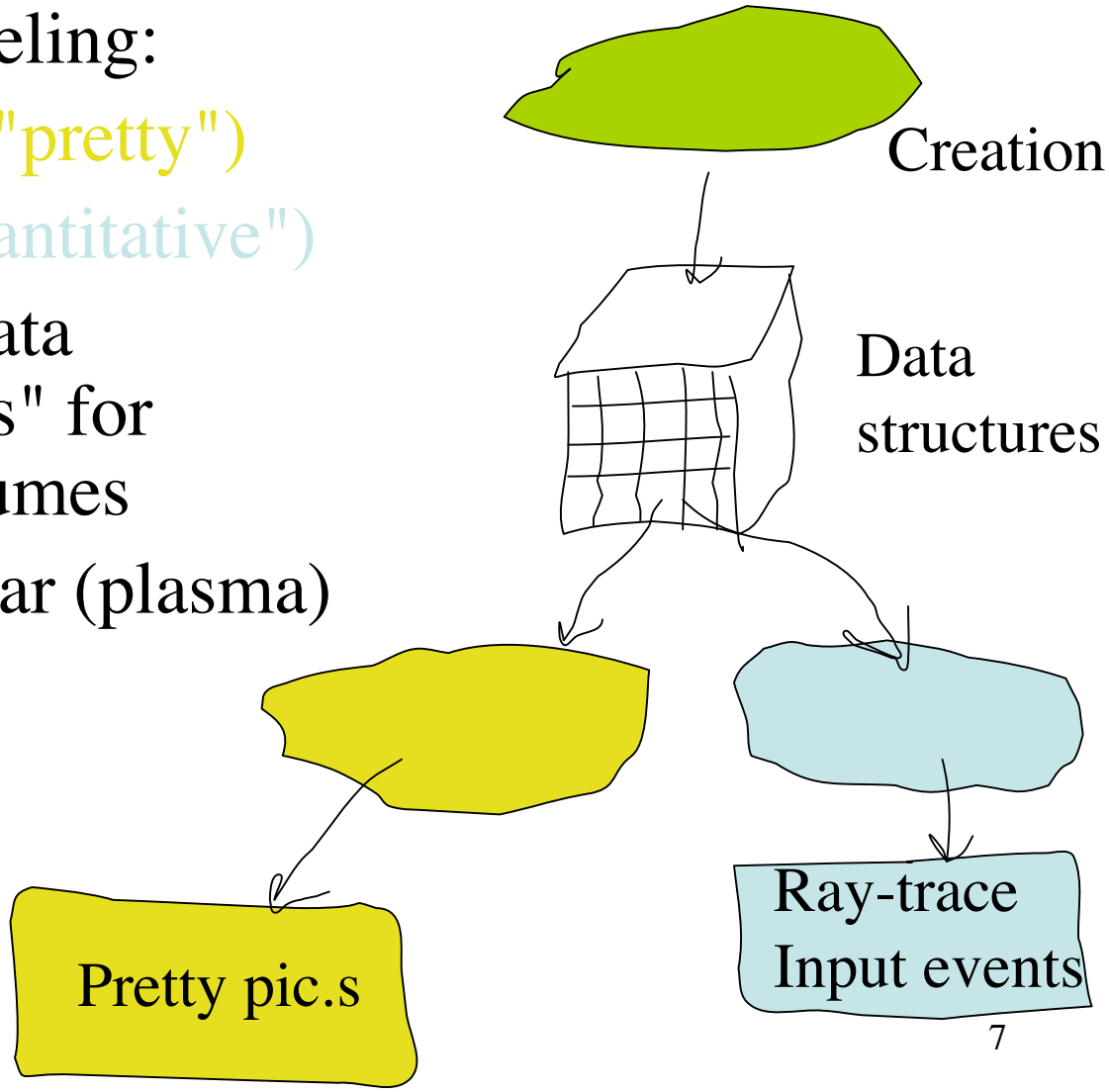


- Contrast the E0102 velocities distribution with Cas A velocities (Willingale 2002, Figure 7)
- Cas A is an inclined ring with red and blue shifted emission generally segregated.



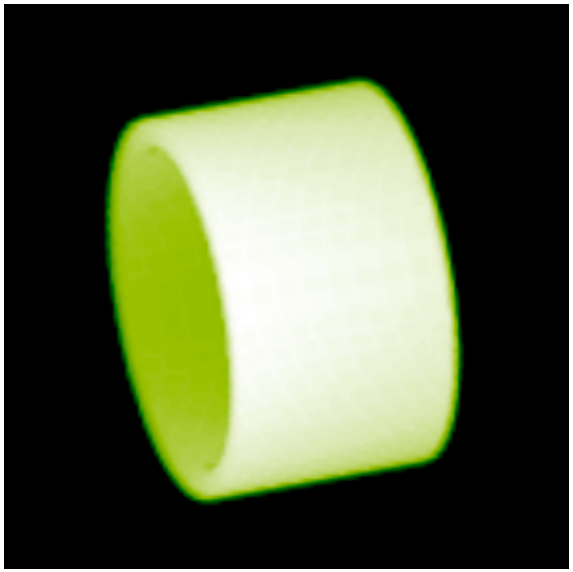
3-D Modeling & Ne X distribution

- Purposes for modeling:
  - Visualization ("pretty")
  - Modeling ("quantitative")
- Building model data structures, "voxels" for optically thin volumes
- 3-D arrays of scalar (plasma) parameters…



Visualizing E0102 cylinder model

- IDL project_vol.pro used here.
- Optically thick and thin views of the cylinder intensity array.



Optically thick view

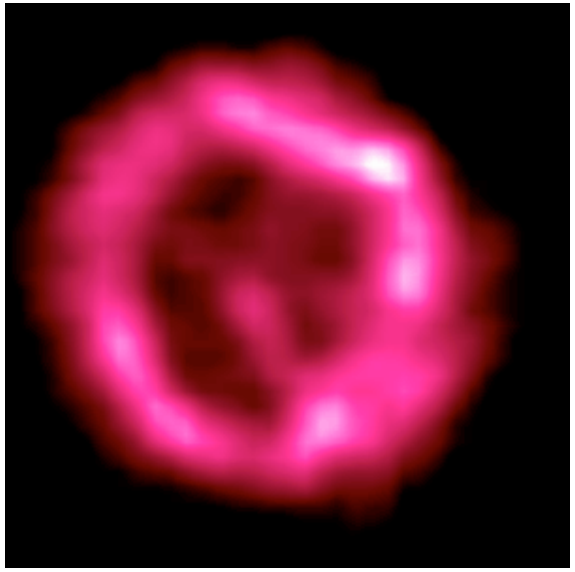
- Maximum value along a ray is used.
- The material has an opacity.
- Depth cuing darkens distant points.

Optically thin view

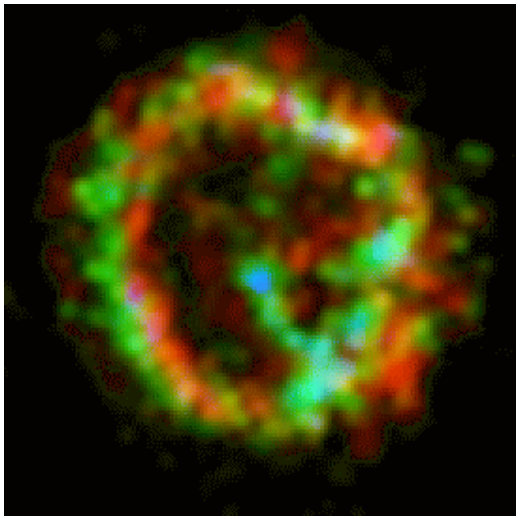
- Sum of values along a ray is used.
- The material has NO opacity.
- No change in intensity with distance.

Model of E0102 nominal viewing angle

E0102 Ne X image



Middle of ring left out



Projection with middle left out - mimics the intensity distribution from the high-V planes.

Are SNRs Optically thin? Everywhere?

- E0102 Ne optically thin?
  - Assuming 1 M_solar of Ne in the cylinder volume get n_Ne ~ 0.02/cm^3. Times length of cylinder, 1.6e+19 cm, gives n_H equiv for the Ne of ~ 0.3e+22 / cm^2: varabs shows 90% transmission above Ne edge - Yes, it's THIN!
- Other [O-rich] SNR? (Cas A, N132D, G292,...)
  - G292.0+1.8: metal rich knots: 1e+17 cm, n ~ 10-1000/cm^3 (Parviz Ghavamian, CfA talk)
  - 1e+18 ions/cm^2 is amount in "solar" N_H of 10^21(O) to 3x10^22(Si)
    - O edge transmission = 60% for N_H = 1e+21
    - Si edge transmission = 85% for N_H = 3e+22

Comments

- E0102 Ne X (12A, 1keV) result made possible by:
  - spatial resolution at scale of few arc seconds
  - Sensitive to V ~ 900 km/s FWHM (E/dE > 300)
  - Second E0102 observation at 90 deg. Roll will improve Ne X; do Ne IX also; similar analysis for O VIII

- 3-D useful for Visualization and Astrophysics
  - Move beyond "uniform volume" models for SNR (and other objects!)

- Are SNRs optically thin?
  - Metal-rich features/knots may be quasi-thin…
  - Is there a way to make quantitative measures to confirm optically thin based on the images themselves?